(NASA-CR-161310) MANUFACTURING PROCESS APPLICATIONS TEAM (MATEAM) Quarterly Status Report, 1 May - 31 Jul. 1979 (IIT Research Inst.) 32 p CSCL 22A

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MANUFACTURING APPLICATIONS TEAM

IIT Research Institute 10 West 35th Street Chicago, Illinois 60616 312/567-4191

August 30, 1979

National Aeronautics & Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Attention: Mr. James H. Ehl, Chief
Tooling Applications Branch
Materials and Processes Laboratory (EH44)

Subject: Manufacturing Process Applications Team (MATeam), Contract No. NAS8-32229, Quarterly Status Report No. 2 for May 1, 1979 through July 31, 1979

Gentlemen:

INTRODUCTION

This is the second quarterly report for the 1979 MATeam program. During the past three months program activity has included the screening of potential NASA problem solving technology, planning candidate RTOP programs, direct technology transfers, and the continued promotion of MATeam goals and objectives.

Technology has been transferred in the form of the Adams Manipulator Arm, A-C Motor Control (modified design) and bolt tension minitor.

Proposed RTOP programs with strong potential include the ion beam coating of cutting tools, the application of micro processors to the A-C motor control, and the orbital tube flaring device.

MATeam promotion continued in the second quarter with presentations to the machine tool and robot industries.

TECHNICAL PROGRESS

Industry Contacts

The MATeam continues to strengthen its communications with industry in presentations and equipment demonstrations to industry associations and selected companies in the industrial sector of our economy. During the reporting period there was a total of two presentations given which described the goals of the MATeam and highlighted related NASA technology.

On June 5 a presentation was given to the 43rd Annual Westinghouse Machine Tool Forum. The Forum had an attendance of approximately 450 engineering and management personnel representing the machine tool industry. Organizations in attendance included Cincinnati Milicron, Gould-Brown-Boveri, and Leybold-Hydraeus. The companies expressed interest in NASA's robot, electron beam welding and magnetic forming technology. In addition, the Forum presentation stimulated industry interest in cutting tool technology, laser wire insulation stripping and welding.

On June 12 a presentation was given to the Board of Directors of the Robot Institute of America (RIA) at the Cincinnati Milicron facility. The NASA robot technology highlighted created considerable interest with those in attendance which included Unimation Inc., Cincinnati Milicron, Auto-Place, Inc., ASEA, Inc. Enclosure (1) includes the brochures prepared by the MATeam which has been forwarded to the robot manufacturers and principal users. MATeam communication with robot manufacturers and users is actively underway.

During the reporting period there were two equipment demonstrations. The first was the orbital tube flaring device which was demonstrated for the Grotnes Machine Works, the Inland Steel subsidiary. The demonstration made a favorable impression on the Grotnes Management and as a result Grotnes has expressed interest in utilizing the process in fittings presently contained in their own hydraulic equipment after laboratory testing of NASA flared samples. Further, there is considerable interest in manufacturing and marketing the system.

On August 20, a demonstration of NASA's robot and manipulator arm technology took place at the Jet Propulsion Laboratory, Pasadena, Calif. Fifteen (15) individuals representing nine (9) companies attended the presentation. Companies represented included Unimation, Inc., Cincinnati Milicron, Boeing, Lockheed and General Dynamics. The sensing and vision systems stimulated the largest amount of interest with the group. There was general agreement that the NASA sensing and vision system technology was unique and has potential application to industry.

There has been a total of 75 contacts with new companies during the second quarter. There has been an additional 18 problem statements identified which brings the total active problem statements to 174.

RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

RTOP Activities

Enclosure (2) is a revised listing of potential RTOP programs which appeared in the last quarterly report. MAT-105 has been deleted since there appears to be a potential patent infringement with existing technology and the amount of NASA supported technology utilized in the basic system design is minimal. MAT-248 has been deleted since application's engineering funding at Exxon has been reduced.

MAT-168 - Industrial Applications of the Orbital Tube Flaring Device

Grotnes has offered an unsolicited proposal to MSFC which is aimed at design modifications that will improve the ease and speed at which the system works. The design changes will improve the marketability of the system in those markets in which penetration is planned by Grotnes. A recent delaying factor has been the discovery of the Teledyne Inc. patent (Pat. No. 3170502-RE-6231) which was sold to them originally by a former NASA employee who held a personal patent on the device. Grotnes legal personnel are presently reviewing the patent and are optimistic that a patent conflict with Teledyne can be avoided. If it is considered that there is no patent conflict and the position of both companies is defined in a letter to NASA (MSFC legal personnel) further considerations of the proposal is anticipated.

MAT-285 - The Ion Beam Coating of Cutting Tools with Carbide Coatings

The Illinois Tool Works Inc. (ITW),Chicago, Ill. is interested in determining if the cutting edge life on hob cutters and conventional cutting tools can be extended using Ion Beam sputtered carbide coatings. ITW is principally interested in titanium carbide coatings and have offered to provide wear and laboratory analysis of samples coated by NASA Lewis in an amount equivalent to $10,000.00. An RTOP program has been prepared and is presently being processed by the Lewis Research Center.

MAT-199 - The Magnetic Hammer and Its Application to Industry

Rohr Marine Inc. is contracted by the Navy to manufacture a high-speed surface craft. Weld distortion problems have occurred with the internal deck plating. At present the distortion is removed by mechanical leveling of the deck plating to a flat position and the application of redundant weld deposits whose stress hold the decking true when the jacking devices are removed. The use of the magnetic hammer (coil patent 3,360972-2 Jan. 1968) has the potential to be a more economical way to remove the distortion. Rohr engineers are presently designing a weldment mockup which will simulate the distortion problem and will be forwarded to Michaud, New Orleans, for straightening trials.

A potential marketing source for the NASA Magnetic Hammer Coil is Maxwell Laboratories, Inc., San Diego, Calif., a major supplier of magnetic forming equipment. Upon a preliminary review of the general coil design Maxwell engineers concluded that it may have strong market potential and have requested detailed drawings for further analysis. Maxwell management are of strong opinion that their existing power supplies have the potential to work effectively with the coil.

A demonstration of the magnetic hammer is being planned for October. Those organizations planning to attend include: Rohr Marine Inc., Maxwell Laboratories, Inc., Hooker Research Center, Harnisfeger, and Gould-Brown-Boveri.

MAT-19 - The Application of Microprocessors to Power Factor Adjustment in A-C Induction Motor Controls

The present NASA power factor control used in A-C induction motors must have its power factor manually set for varying motor designs to operate at optimum efficiency. Thus, versatility of the controller is limited in some applications where the same control will be used on different devices.

In order to optimize application of the controller it is proposed that a development program be initiated that will result in application of a microprocessor to the basic NASA motor control. The microprocessor will enable automatic adjustment of the power factor to varying device designs and conditions. The company "Solid State Relays, Inc." has expressed interest in co-funding the program. The RTOP has been forwarded to Headquarters by MSFC and is presently being considered for funding by the Department of Energy.

Direct Technology Transfers

Vim Systems, Inc., Syracuse, N.Y. has applied for a non-exclusive patent license on the total Adams Manipulator Arm System (Tech Brief B73-10204). Vim has developed the system for production assembly tasks. The initial prototype is scheduled to undergo trials in January 1980.

The modified design of the A-C motor control has been transferred to Furnas Electric Co. of Batavia, IL. MATeam has been informed by Furnas, management that a small division consisting of engineering and marketing personnel has been organized to support production of the controller. Prototype controllers have been built and are presently being evaluated on electric motors at the Batavia facility.

The Bolt Tension Monitor (Langley) has been transferred to the Zytel Corporation of Lombard, IL. Zytel has made some modifications to the basic system and feel that earlier technical problems related to erroneous signals have been resolved. Zytel is presently organizing their market plan. Zytel marketing plans will be discussed in the next quarterly report.

FUTURE PLANS

Presentations and Press Releases

Enclosure 3 includes the scheduled presentations that are presently planned for the program year. Presentations are being planned for the Manufacturing Engineering Branch at the Rock Island Arsenal, the Laser Institute of America and Deere & Company to name a few.

Enclosure 4 is the press release relating to the early warning bearing failure detection capabilities developed by NASA. The release is principally directed at the manufacturing industry.

SUMMARY

The MATeam continues to become a valuable problem solving source for industry and federal agencies. RTOP activity with federal agencies will be an area in which there will be greater effort devoted in the balance of the program year.

Respectfully submitted,

IIT RESEARCH INSTITUTE

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ERB/ds

N A S A

ROBOT TECHNOLOGY

AVAILABLE TO

INDUSTRY

ENCLOSURE 1

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VISION SYSTEMS

This equipment was developed for the rock sampling robot vehicle at Jet Propulsion Laboratories. The stereoscope vision system enables the rover to maneuver to reach a rock, determine the short side of the rock and then position the manipulator arm and gripper to fetch the rock.

Two semiconductor cameras two feet apart are mounted on a pole on the rover about 4 ft. high off the ground. The stop settings on the cameras give them a large depth of field. The picture of 188 pixels by 244 lines is scanned every one thirtieth of a second and stored into a high speed memory that can be accessed by the computer analyzing the picture. Basically the problem is that of recognizing similar images in the two camera images and then calculating from the two best defined objects, the distance and angle to the defined object.

The picture processing is carried out in four steps.

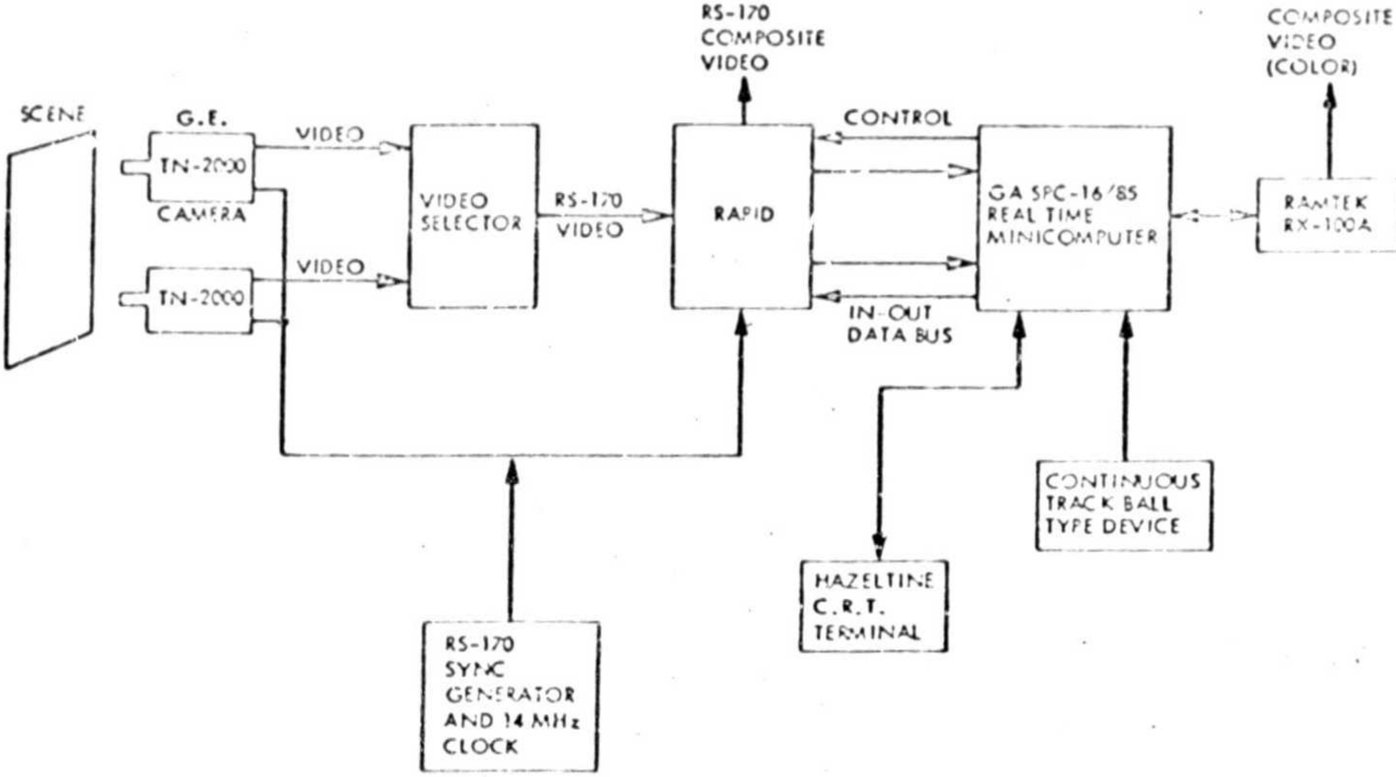
1. In the first step, edge enhancement is accomplished by considering the picture four pixels at a time and subtracting the light values between the four pixels in the group and averaging them. Large numbers indicate that sudden changes in light value occurred due to an object edge passing through the four group.

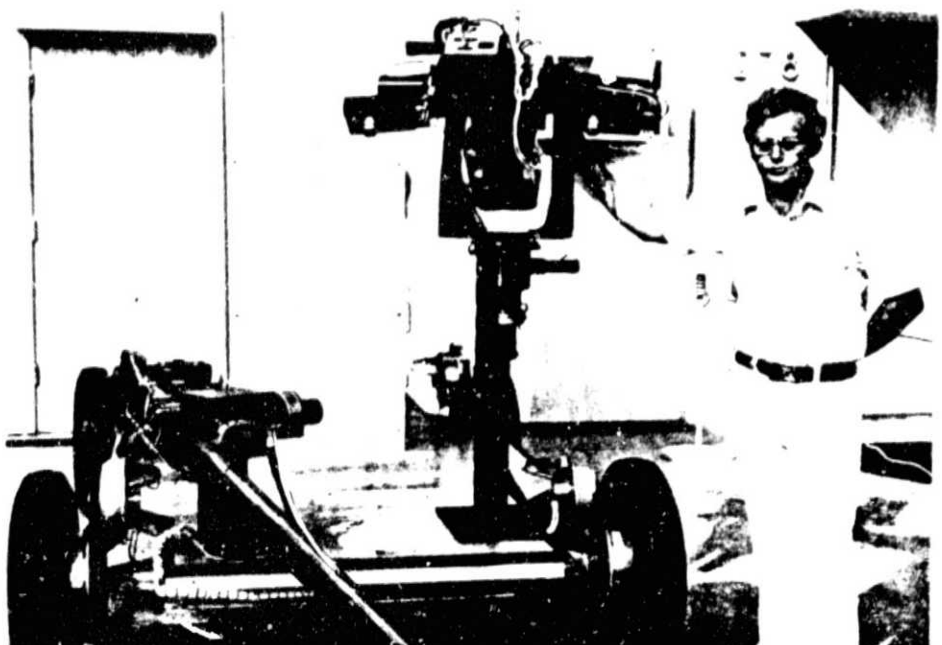
2. In the second step, the picture is scanned again to obtain a list of regions that correspond to possible objects of interest. Regions are defined as connected clusters of pixels that exceed an edge confidence threshold.

3. In the third step, one region is selected from the list and the full digitized image is read into the memory again from the cameras. From the full picture and the previously defined regions, the outline of the object is obtained by a region growing algorithm. From this the shape of the object can be determined as well as the short axis required for gripper.

4. In the fourth step using the positions of both image centroids in each picture the computer calculates the distance and angle to the object enabling the manipulator to fetch the item.

The sketches below show the arrangement of the cameras, memories and computer.





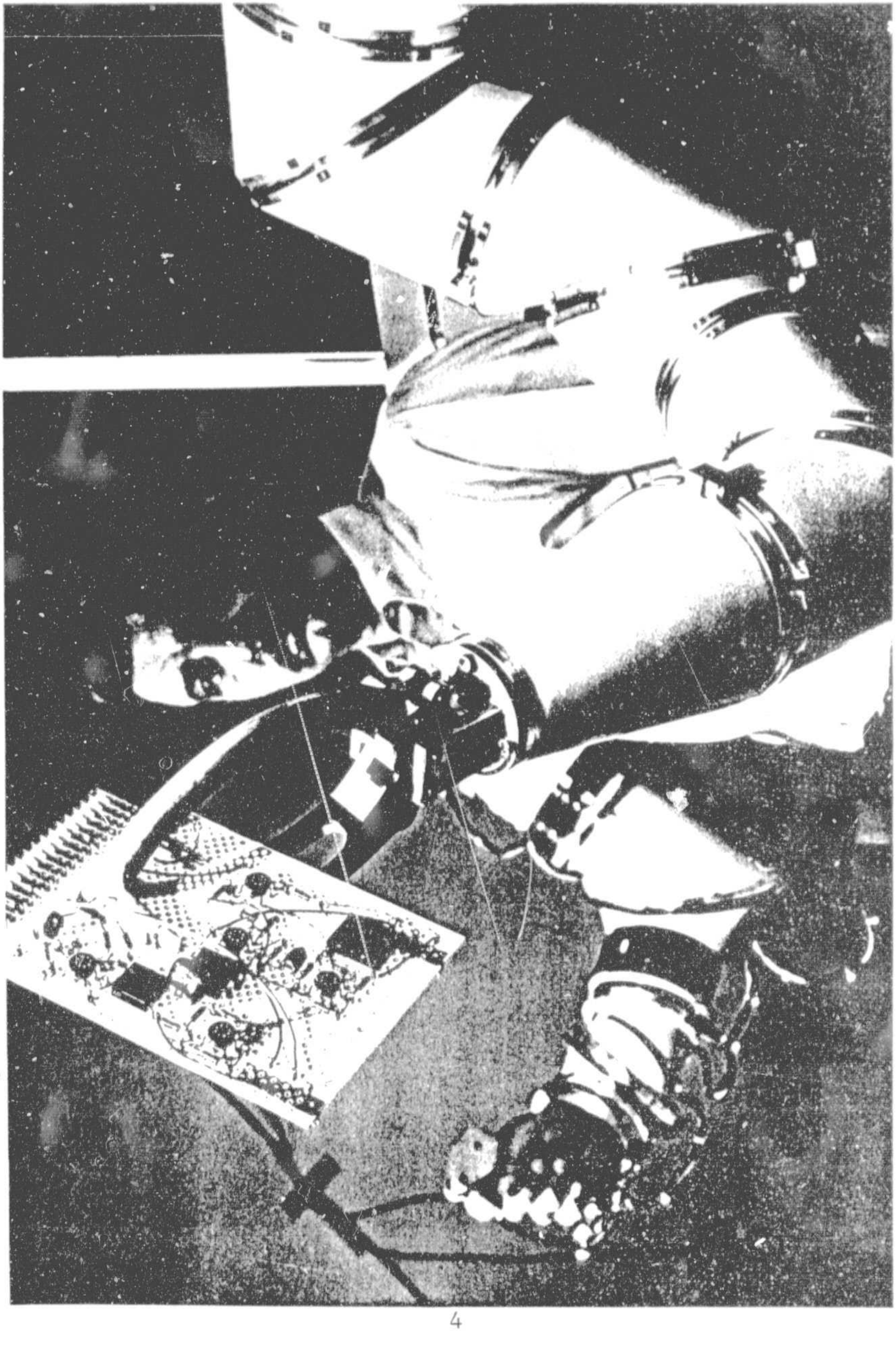
ORIGINAL
OF POOR

ORIGINAL IS
OF POOR

THE AMES ARM

This arm was developed at Ames Research Center locally by Dr. Uykukal originally as it has rigid tubes with sealed joints, a space suit to match the human arm joints. Two identical arms are being used in a master-slave arrangement with the master as a position controller. The joint positions are determined by potentiometric pickoff and the difference between the master arm potentiometers showing desired position and the slave arm potentiometers showing present position, drives the servo amplifiers to correct the difference. At Jet Propulsion Labs voice commands can be used to direct the arm as described later in this brochure.

The arm has six degrees of freedom with joints as in the human frame it encloses. The length of the upper and lower arms are approximately 1 foot. The arm is fitted with a parallel jaw gripper.



ADVANCED ACTION MANIPULATOR SYSTEM

This arm was developed by General Electric, Space Re-Entry Systems Division for Marshall Space Flight Center for use as laboratory testing tool. The arm is part of a master-slave system where the master arm uses position control to set the electrically driven slave. The control system uses potentiometers in the master whose signals are compared with the potentiometers in the slave. The difference between the two potentiometers on each axis constitute an error signal which drives the motors on the slave via amplifiers.

The arm has six degrees of freedom, three in the shoulder; azimuth, pitch and roll, one in the elbow; pitch, and two in the wrist; pitch and roll. The azimuth is set 30° from the vertical. The length of the upper arm is 18 inches and lower 24 inches. The end effector has parallel jaws.

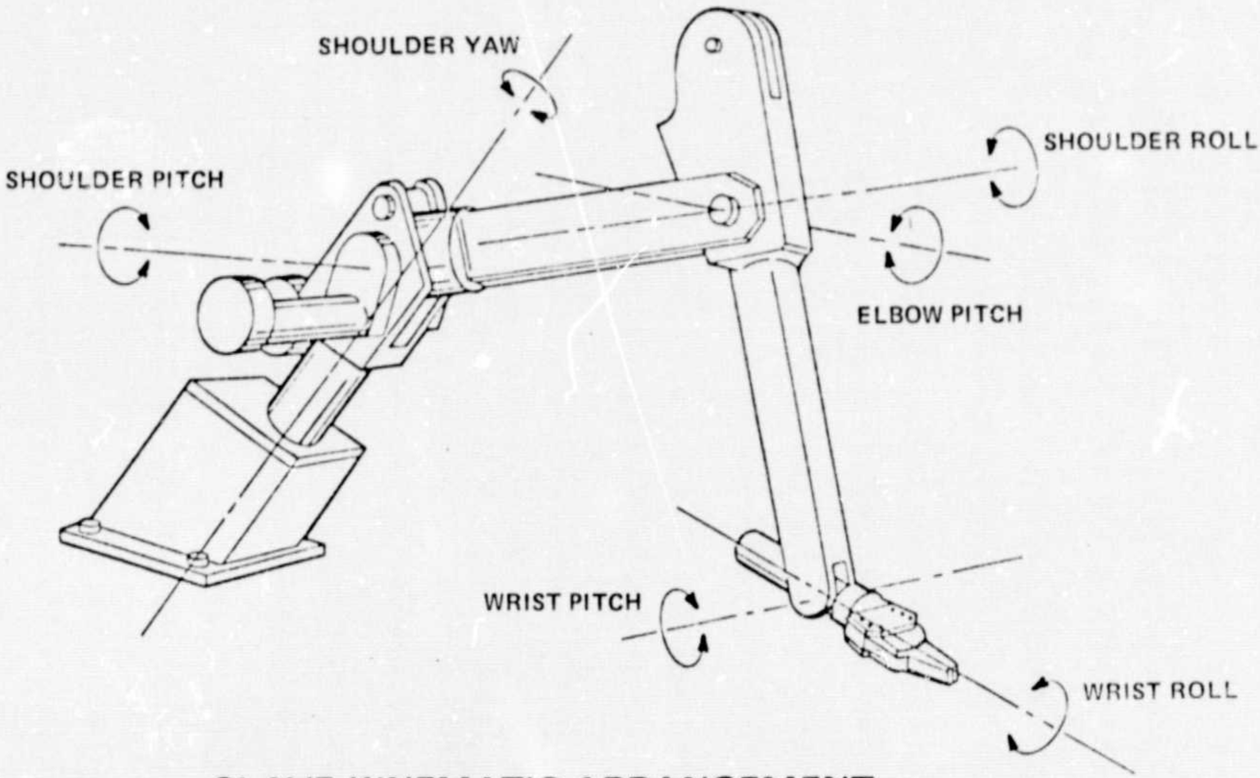
The performance of the arm is as follows:

The load capacity is 6 pounds

The positional accuracy is 0.1 inches

The maximum reach is 3.5 feet and

The maximum speed is 30 inches per second.



SLAVE KINEMATIC ARRANGEMENT

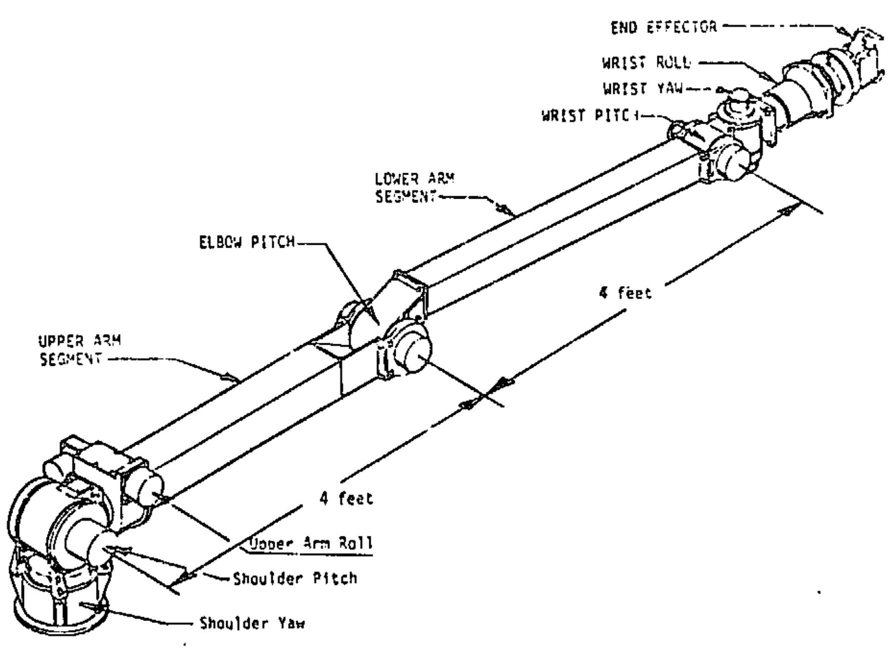
PROTO FLIGHT MANIPULATOR ARM

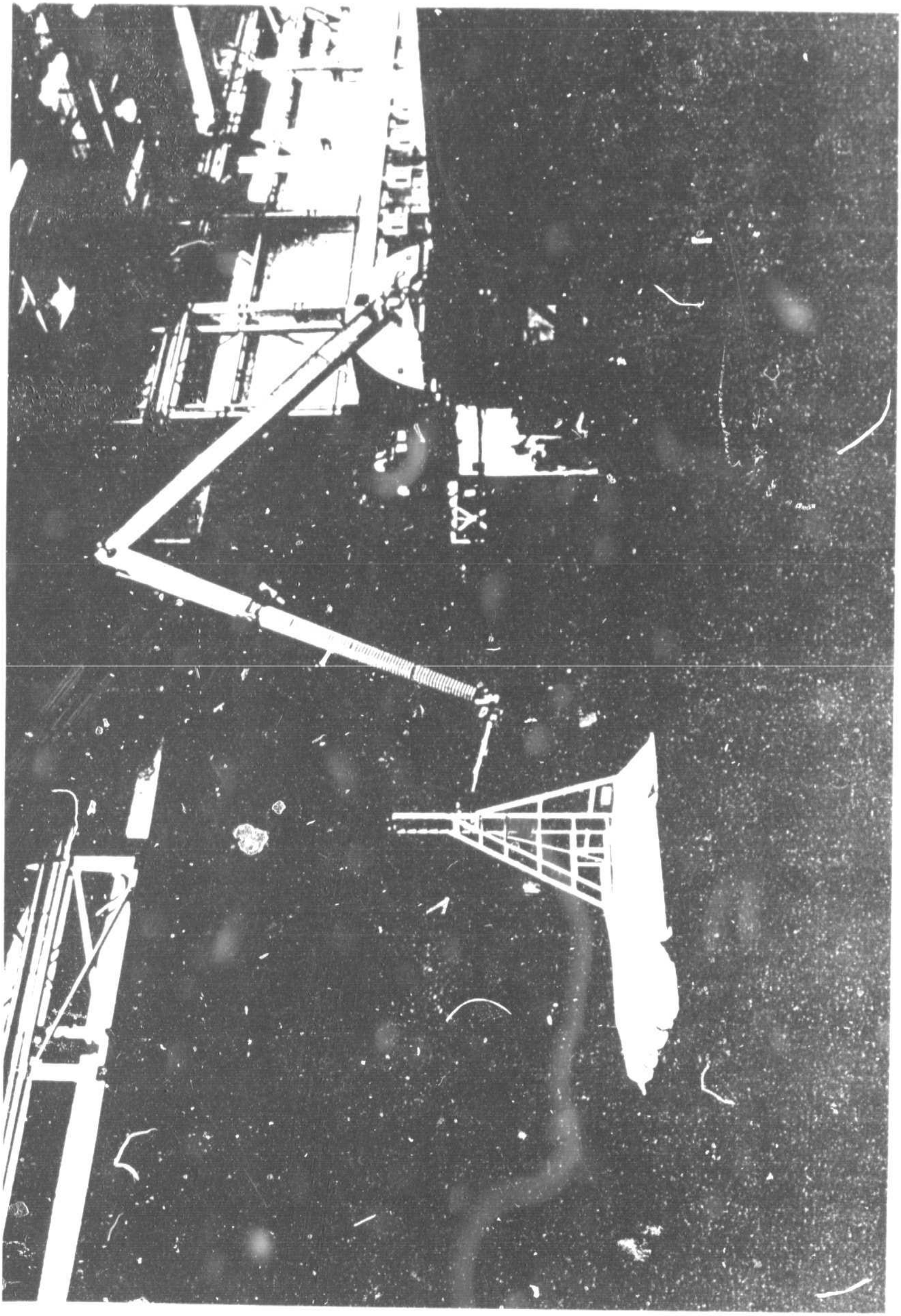
This arm was developed by Martin Marietta Corp. for Marshall Space Flight Center for use as a model for the Shuttle Orbiter. The arm is mounted in the Orbiter Space Craft and is rate controlled by a pistol grip unilateral controller. The control system uses an SEL 840 computer to compute the motions of the joints and to integrate the joint velocity transducer signals to determine position. There is also a small replica arm with position control that was used in arm checkout.

The arm has seven degrees of freedom total but one of these, the shoulder roll is used only for stowing the arm and hence has indexing rather than proportional control. The degrees of freedom are shoulder yaw, shoulder pitch, shoulder roll, elbow pitch, and wrist yaw pitch and roll. The length of the upper and lower arms is 4 feet in the lab model. The length of each arm will be 15 feet in the Shuttle Orbiter. Substitute Orbiter arms are presently in use at Johnson.

The performance of the arm is as follows:

> Since the arm is used in space, load capacity has little meaning. However, the jaws can exert a grip of 25 pounds.
>
> The positional accuracy is 0.05 inches.
>
> The maximum speed of movement at each joint is 2 eadian per second.
>
> The maximum reach is 8 feet in the lab model, 30 feet in the Orbiter model.
>
> The arm is fitted with a parallel jaw and effector.



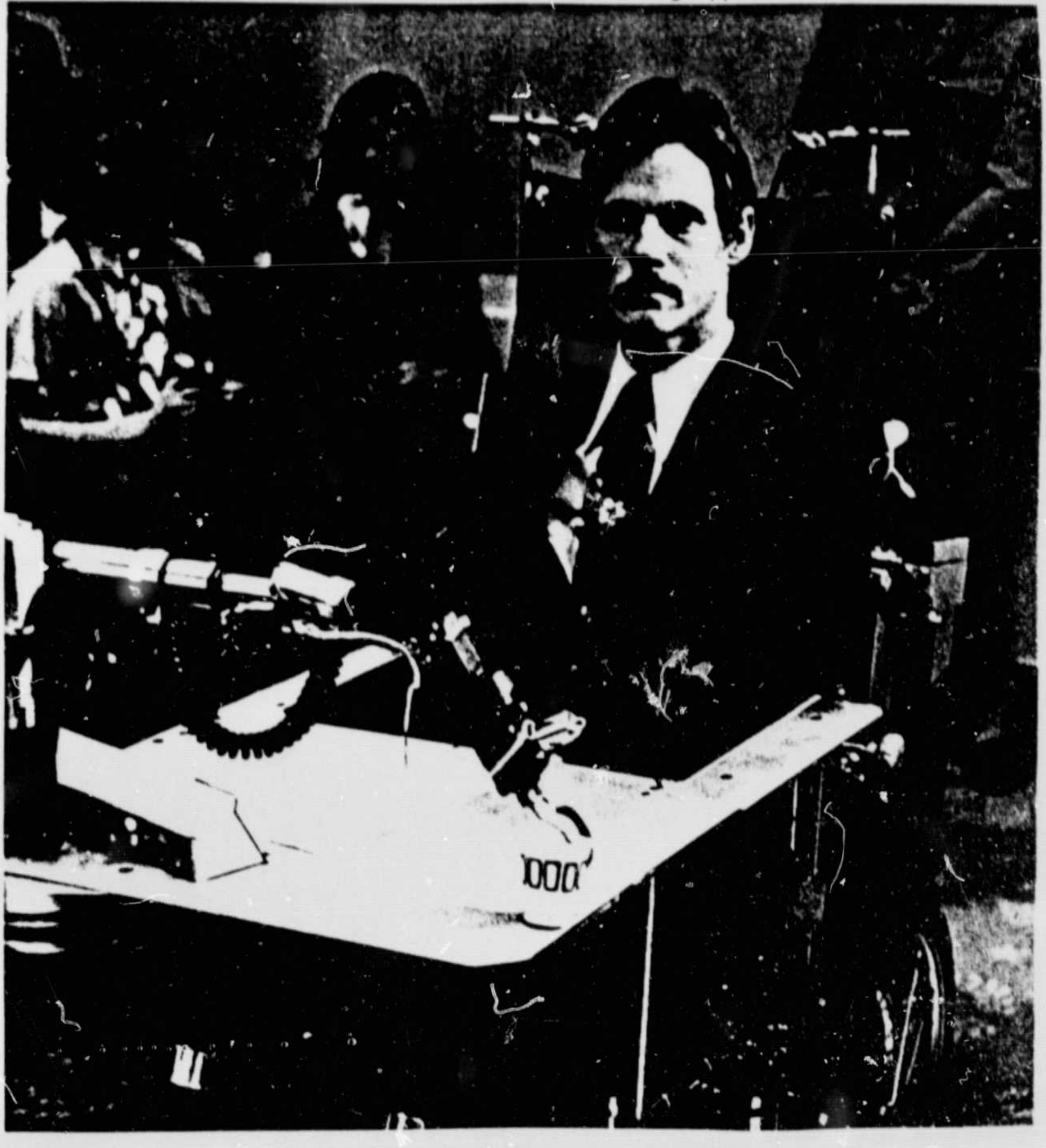


THE RANCHO ANTHROPOMORPHIC ARM

This arm was developed at Los Amigos Hospital in Los Angeles by Dr. Allen and his team under contract for Marshall Space Flight Center. The arm is used to augment disabled limbs or replace missing limbs.

A variety of control schemes have been built. In one, signals from the nerve endings are amplified to control the arm, in another a tonque operated "joystick" controls the movements. In another recent application a voice operated detector similar to the JPL detector controls the arm.

The arm has six degrees of freedom matching the human arm. The length of the upper and lower arm is 1 foot approximately. The manipulator is fitted with the Dorrance gripper.

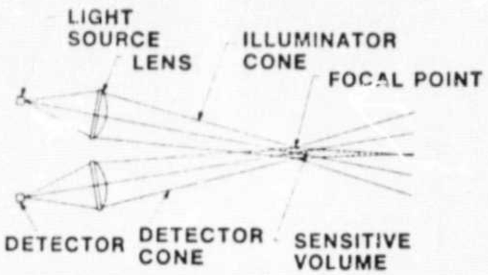


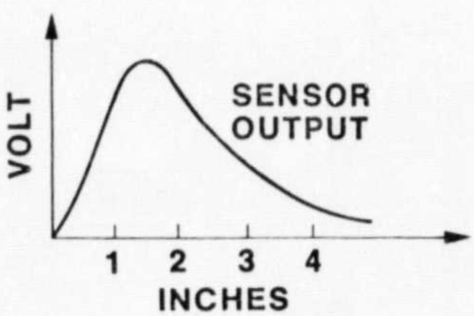
INFRA RED PROXIMITY DETECTOR

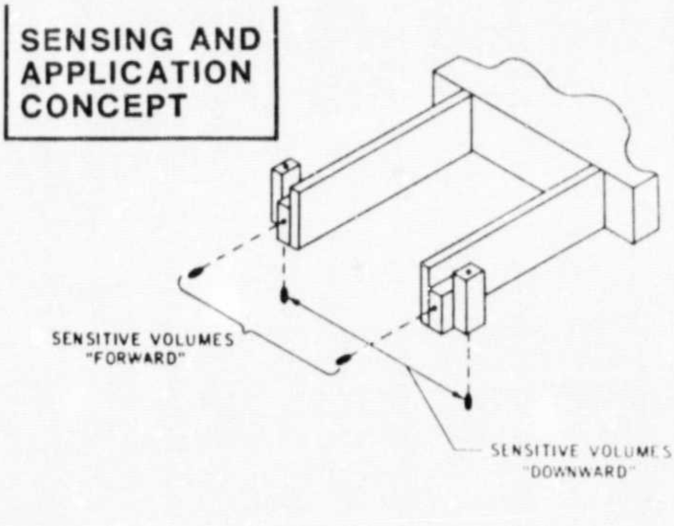
The infra red proximity sensor described here was developed by A.R. Johnson of Jet Propulsion Labs for use on manipulator arms. Such sensors are required because of possible misalignment between the end effector and the item to be picked up. The misalignment occurs either through operator error in an operator system or through tolerance in item placement in a programmed control pickup situation.

The proximity device consists of a light source and a light detector whose ray paths cross some 6 inches in front of their focessing lenses such that light reflected from the detected object in the beam crossing area, will be captured by the photocell. This is shown in the accompanying sketch.

The source for the proximity device is a light emitting diode radiating at 940 nmx in the infrared part of the spectrum. The detector is a infra red sensitive phototransistor having preceding 1 mm aperture and ambient light filter. Both source and detector have collinating lenses ahead of them so that the parallel beams are focussed to point "sources".







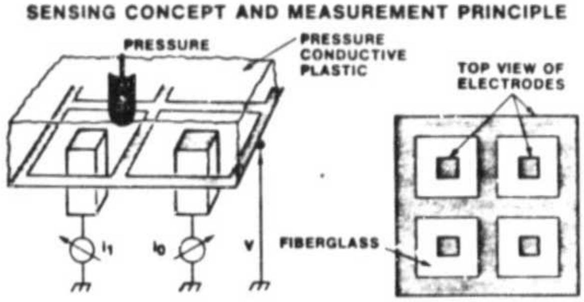
TOUCH SENSORS

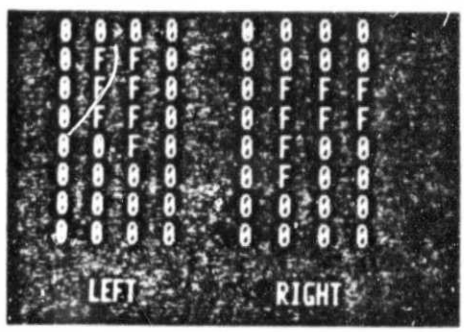
The touch sensor described here was developed at Jet Propulsion Laboratories by Dr. Antal Bejczy and associates for use on manipulator arms. Such sensors are required for advising the operator if the item to be grasped is barely in the jaws of the end effector.

The sensor works on the principle that an suitable conductive plastic materials suffers linear decrease in resistance proportional to applied to the pressure. The voltage is applied to the material by strips of conductive film which are bonded to the plastic surface. The decrease in resistance when pressure is applied is detected by a current sensing device. In order to detect position on the conductive sheet, the sheet is divided into a matrix of squares, 4 x 8 in formation, each square being 4 mm on a side. Each area has on the same side of the sheet a centered dot of metallization of a pickoff point. The uniformity of the material enabled the pick off signal to be quantized to 16 steps having values between 0 and 'F' hexadecimal.

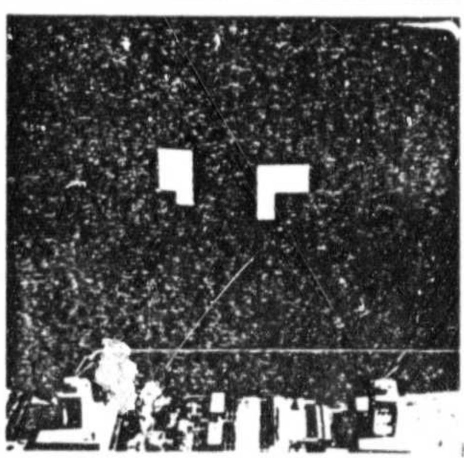
For display, a CRT delineates the 4 horizontal x 8 vertical matrix area and places into each square, the above hexadecimal value. Thus, if the bottom 4 squares show 'F' and the rest '0' then the operator infers the object is barely grasped.

SENSING CONCEPT AND MEASUREMENT PRINCIPLE





NUMERICAL (HEXADECIMAL) DISPLAY OF CONTACT AREA AND PRESSURE DISTRIBUTION RANGING FROM "0" TO "F"



COLOR GRAPHICS DISPLAY OF CONTACT AREA AND PRESSURE DISTRIBUTION

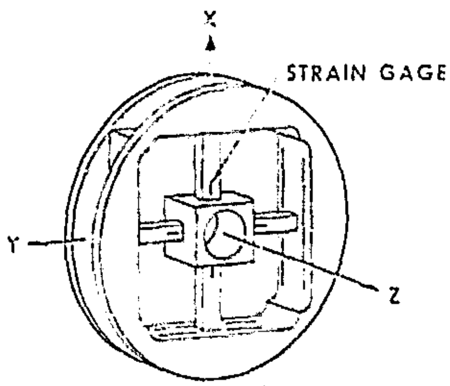
0.5 SQUARE INCHES SENSITIVE SURFACES IN CONTACT WITH SMALL, REGULAR OBJECTS

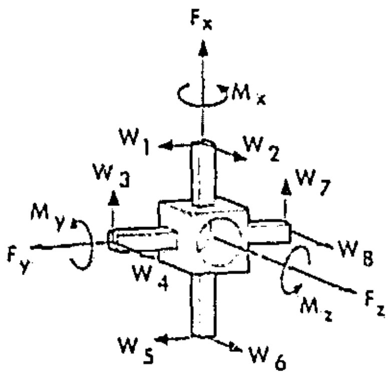
THE WRIST SENSORS

The wrist sensor described here was designed by Dr. Antal Bejczy and colleagues at the Jet Propulsion Labortary for use on manipulators. The sensor was built by Vicarm of Los Angles. The sensor is required for operations of bolt tightening or handling long loads. The unit senses the three orthogonal forces and three orthrogonal torques experience by a manipulator wrist under differing conditions.

The principle of load detection rests on straing gauges attached to the 4 square section spokes of a Maltese brass shape. Each side of every spoke carries a strain gauge for total of 16 in all. The front and back of each spoke has the strain gauges connected together in a voltage divider pair hence there are eight output signals, W_1 through W_8. An attached computer makes and 8 to 6 transformation to derive the orthogonal forces and torques.

A 6 bar bar-chart CRT displays the forces experienced by the wrist. A representative set of cases are shown below with a bar chart accompanying each photograph. Note that the gripper is turned 90° on its edge so the X axis displayed is due to vertical physical loading.





TRANSFORMATION MATRIX
UNDER IDEAL CONDITIONS

$$
\begin{array}{c}
\text{FORCES} \\ \text{AND} \\ \text{TORQUES} \\ \text{REFERENCED} \\ \text{TO} \\ \text{X-Y-Z} \\ \text{SENSOR} \\ \text{COORDINATES}
\end{array}
\begin{bmatrix} F_x \\ F_y \\ F_z \\ M_x \\ M_y \\ M_z \end{bmatrix}
=
\begin{bmatrix}
0 & 0 & k_{13} & 0 & 0 & 0 & k_{17} & 0 \\
k_{21} & 0 & 0 & 0 & k_{25} & 0 & 0 & 0 \\
0 & k_{32} & 0 & k_{34} & 0 & k_{36} & 0 & k_{38} \\
0 & 0 & 0 & k_{44} & 0 & 0 & 0 & k_{48} \\
0 & k_{52} & 0 & 0 & 0 & k_{56} & 0 & 0 \\
k_{61} & 0 & k_{63} & 0 & k_{65} & 0 & k_{67} & 0
\end{bmatrix}
\begin{bmatrix} W_1 \\ W_2 \\ W_3 \\ W_4 \\ W_5 \\ W_6 \\ W_7 \\ W_8 \end{bmatrix}
\begin{array}{c}
\text{FORCES} \\ \text{SENSED} \\ \text{AT} \\ \text{SPOKE} \\ \text{ELEMENTS}
\end{array}
$$

FORCE–TORQUE MEASUREMENTS AND DISPLAY

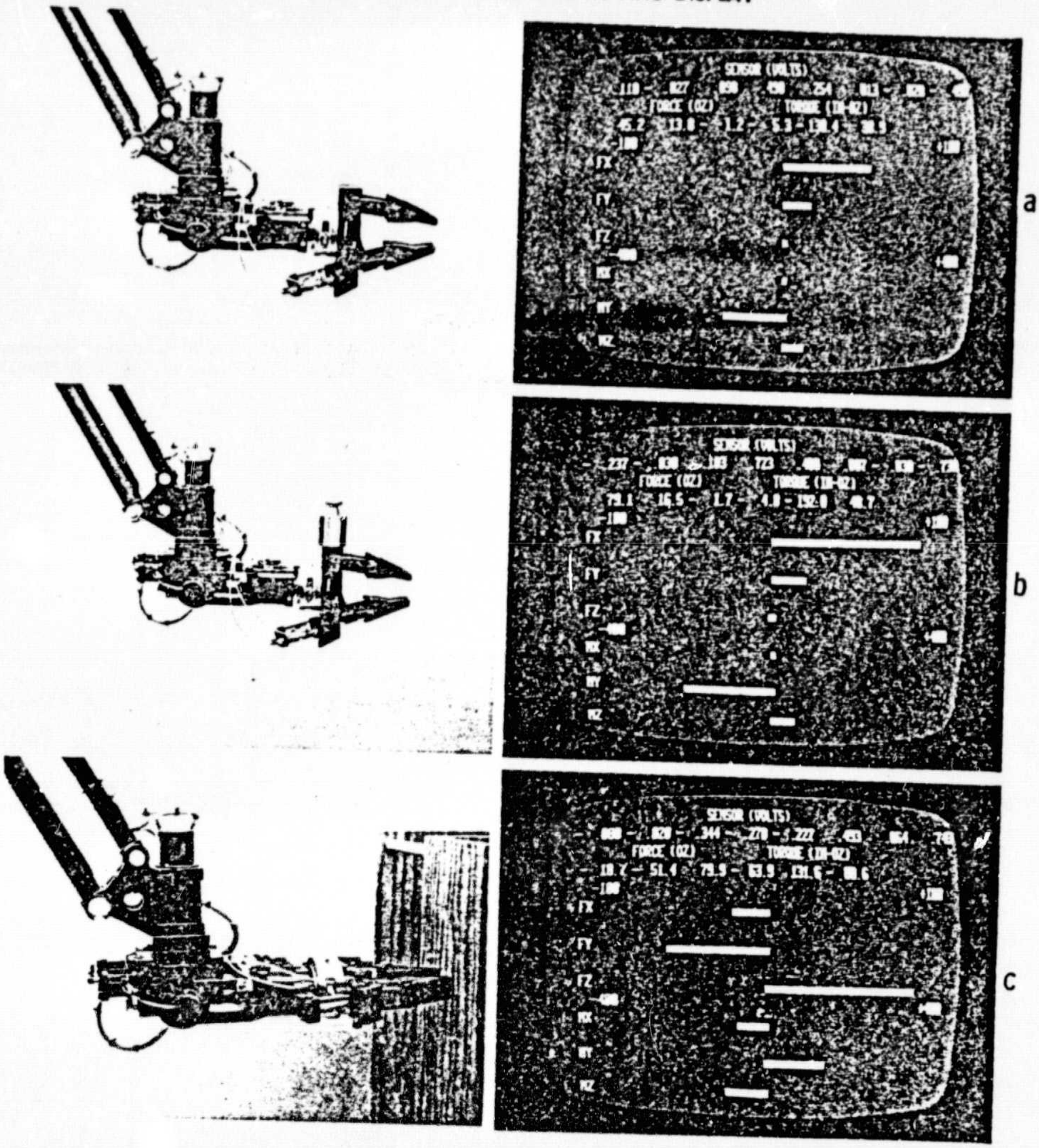


Figure Force-Torque Sensor Information Graphics Display

THE VOICE CONTROL SYSTEM

This system was developed by Dr. Antal Bejczy and colleagues at Jet Propulsion Laboratory for use in guiding manipulators. The system was developed to aid operators in controlling manipulators since aural feedback signals can be detected without watching an indicator display.

The JPL system uses a middlesized commercially-available speech recognition system built by Interstate Electronics of California. The system consists of a word recognizer unit, a speech synthesizer, a word display unit and a computer. The operator inputs information using a headset. Commands are given to the system both to guide the arm and change the displays assisting the operator to use the arm.

There is a defined vocabulary of some 200 words relating to the movement, axis, distance, and speed for controlling the arm. A syntax defines the order in which the words need to be spoken. A chart of the syntax appears below.

The control of the whole system revolves around a minicomputer network having an Interdata 70 as the main mode. The signals from voice recognition unit are passed into a Nova 2 computer which checks them and passes them to the Interdata 8/16 computer which controls the manipulator arm. The significance of this is that the voice commands guide the arm close to the object to be picked up and the previously discussed sensors guide the arm for final positioning. Voice commands then close (or open) the end effector jaws.

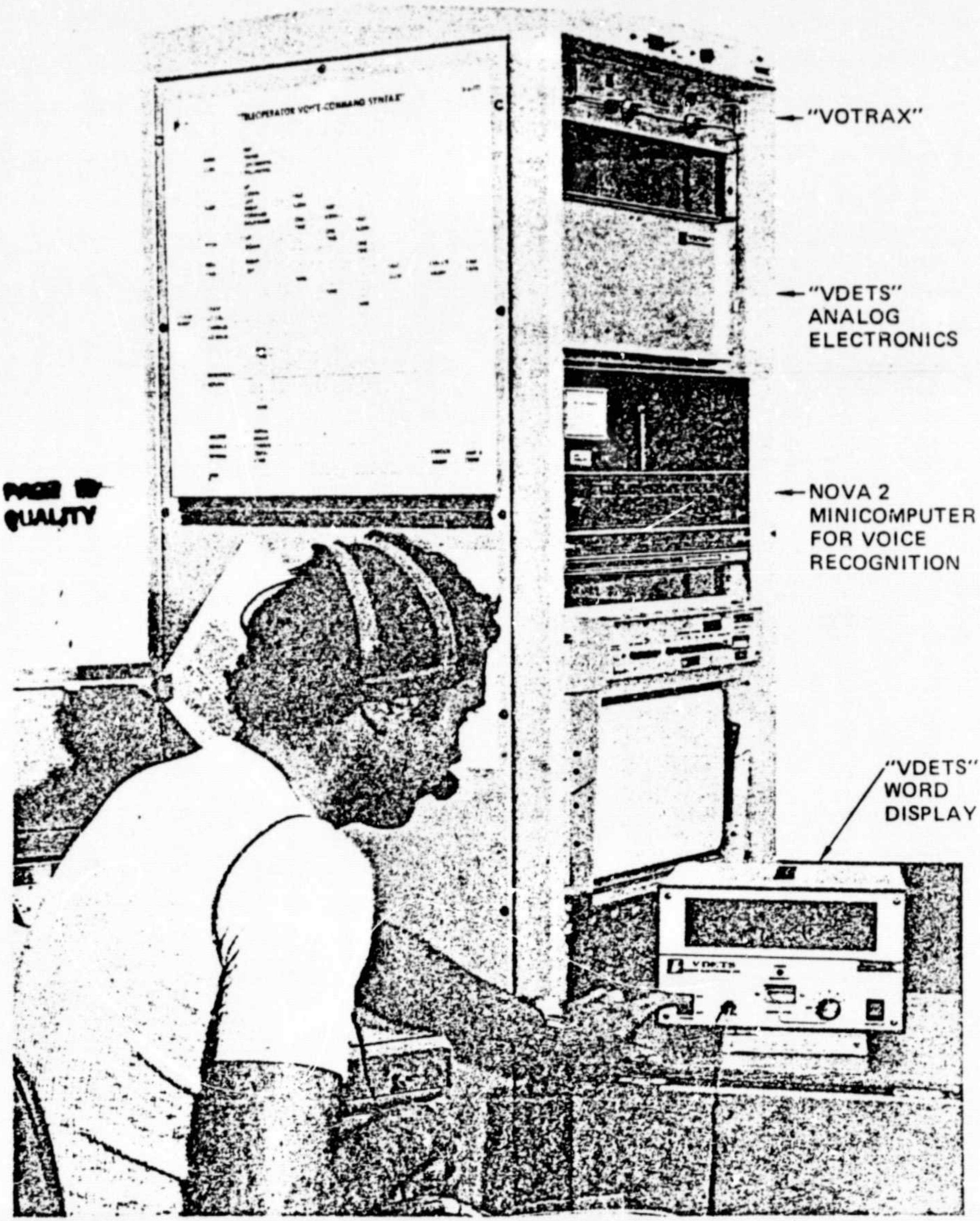
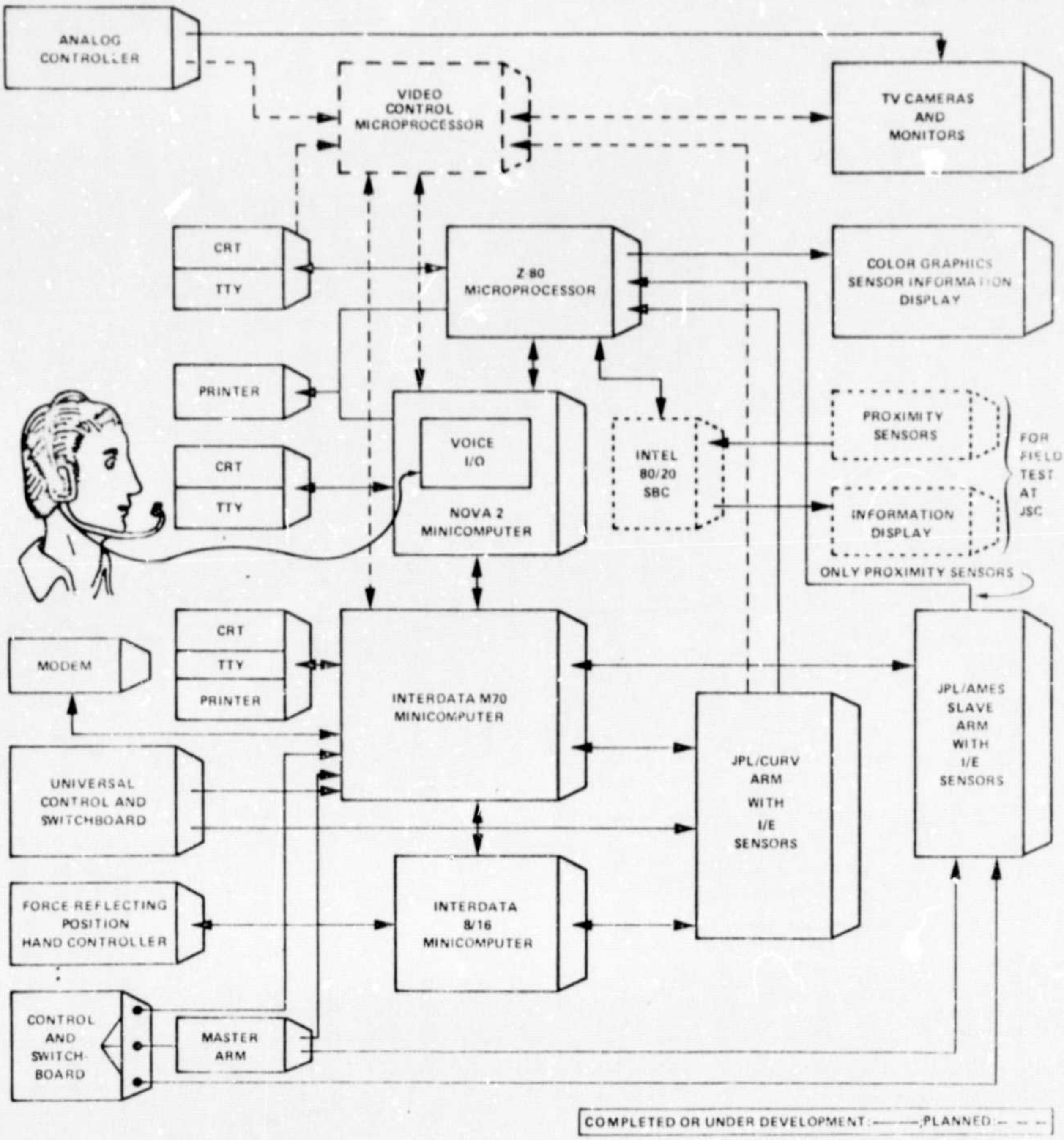


Figure 3. Voice Input/Output System Installation
at the JPL Teleoperator Laboratory



ANALOG CONTROLLER
VIDEO CONTROL MICROPROCESSOR
TV CAMERAS AND MONITORS
CRT
TTY
Z 80 MICROPROCESSOR
COLOR GRAPHICS SENSOR INFORMATION DISPLAY
PRINTER
VOICE I/O
NOVA 2 MINICOMPUTER
INTEL 80/20 SBC
PROXIMITY SENSORS
INFORMATION DISPLAY
FOR FIELD TEST AT JSC
ONLY PROXIMITY SENSORS
CRT
TTY
CRT
TTY
PRINTER
MODEM
INTERDATA M70 MINICOMPUTER
JPL/AMES SLAVE ARM WITH I/E SENSORS
UNIVERSAL CONTROL AND SWITCHBOARD
JPL/CURV ARM WITH I/E SENSORS
FORCE REFLECTING POSITION HAND CONTROLLER
INTERDATA 8/16 MINICOMPUTER
CONTROL AND SWITCH-BOARD
MASTER ARM
COMPLETED OR UNDER DEVELOPMENT: ——; PLANNED: – – –

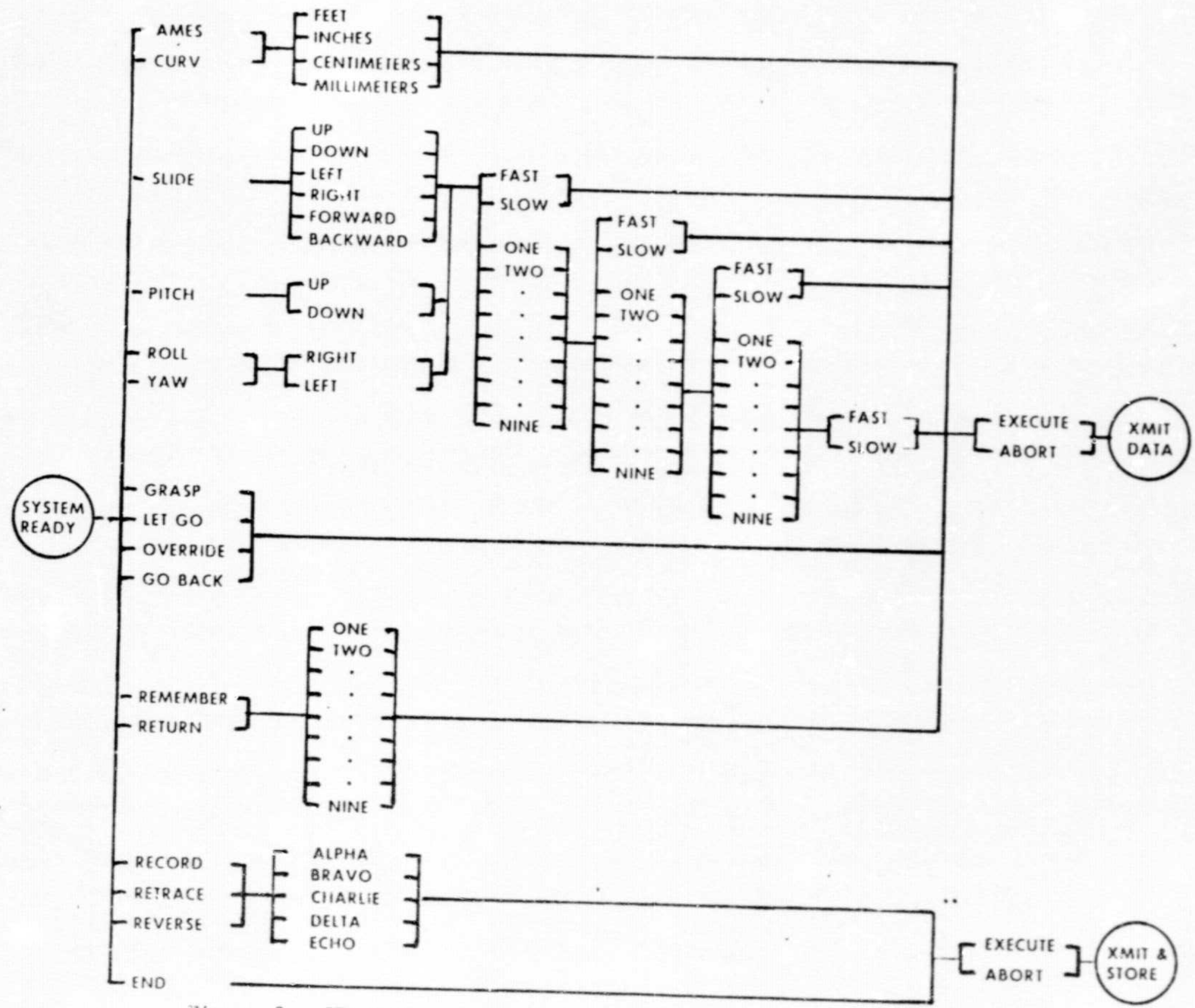


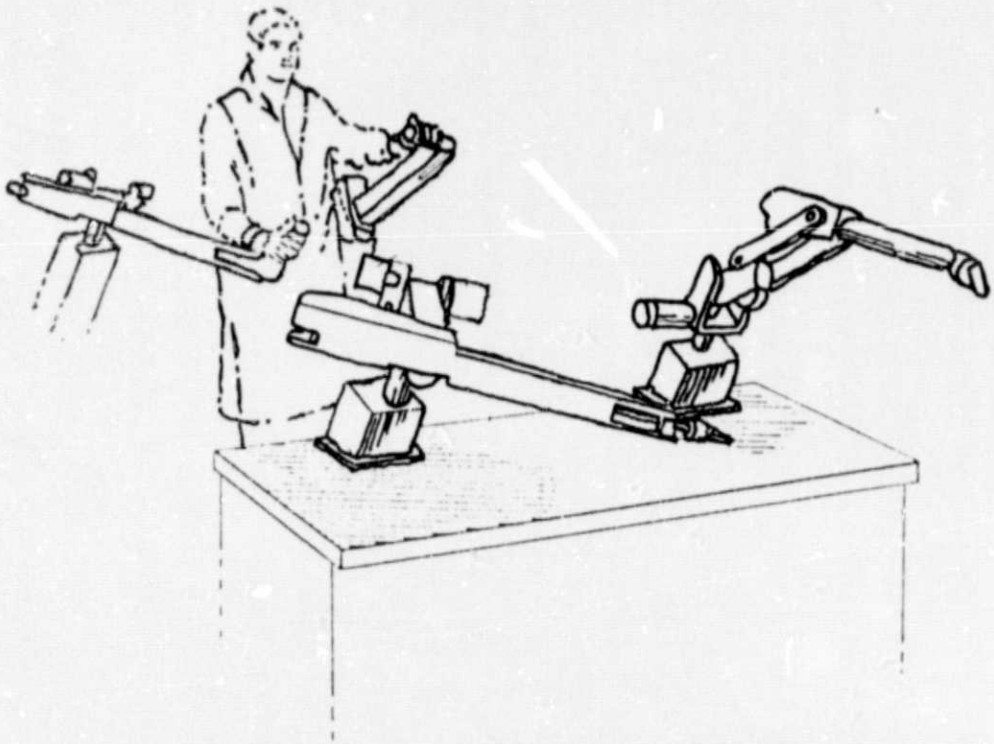
Figure 2. JPL Teleoperator Voice Command System Syntax Structure

ADVANCED ACTION MANIPULATOR CONTROLLER

The ADAMS system uses a slave arm identical in form to the master arm moved by the operator. This is a unilateral position control system meaning that force encountered by the slave arm is not transmitted back to the master and an inch of master movement results in an inch of slave movements.

The master arm has an upper and lower arm lengths of 18 inches and 24 inches respectively. The sections of the arm are individually counterbalanced, reducing operator fatigue.

The master arm angle position transducers are multiturn potentiometers driven by spur gears from the speed reduction train.



THE SIX AXIS FORCE REFLECTING CONTROLLER

This controller is a bilateral position controller meaning that forces experienced by the slave arm are linearly transmitted back to operator gently resisting his arm movement.

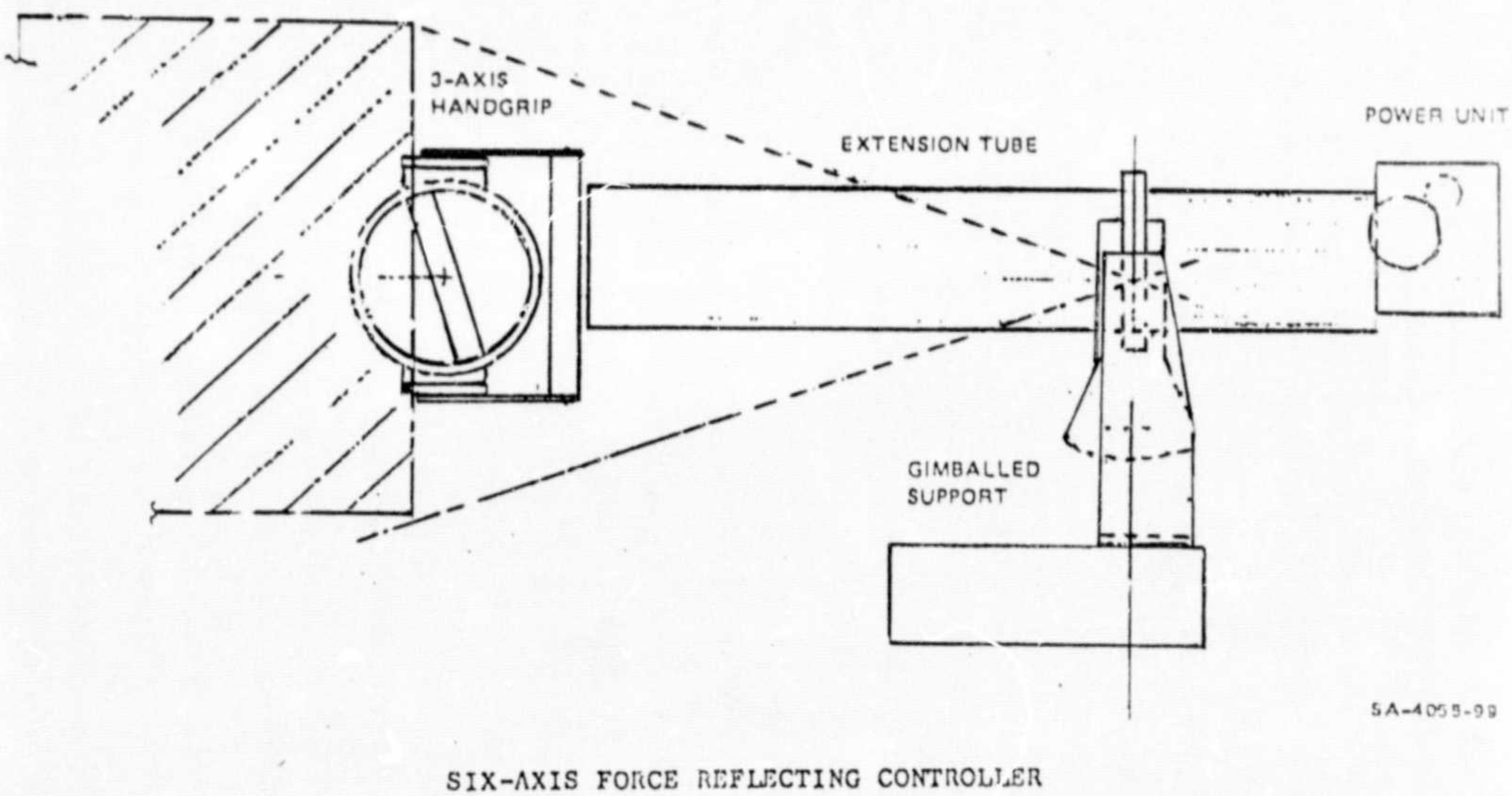
The controller geometery resembles a three axis fully gimballed handgrip mounted on an extension tube which slides telescopally in and out of a gun barrel in a mounting. The first three axis of movement arise from the gimballed mount.

The fourst axis is a telescopic slide, the fifth is the elevation of the telescopic slide and the sixth axis is the azimuth rotation.

To counterbalance the weight of the arm, all the activators are mounted in a tube extension to rear of the azimuth pivot. The actuators drive their respective axes through flexible drives running through the tube. Motion of the joints is detected by potentiometer transducers.

A condensed specification is as follows:

- The gimballed hand grip can move through a cube area 1 foot on each side
- The telscopic slide can move in and out 15 inches.



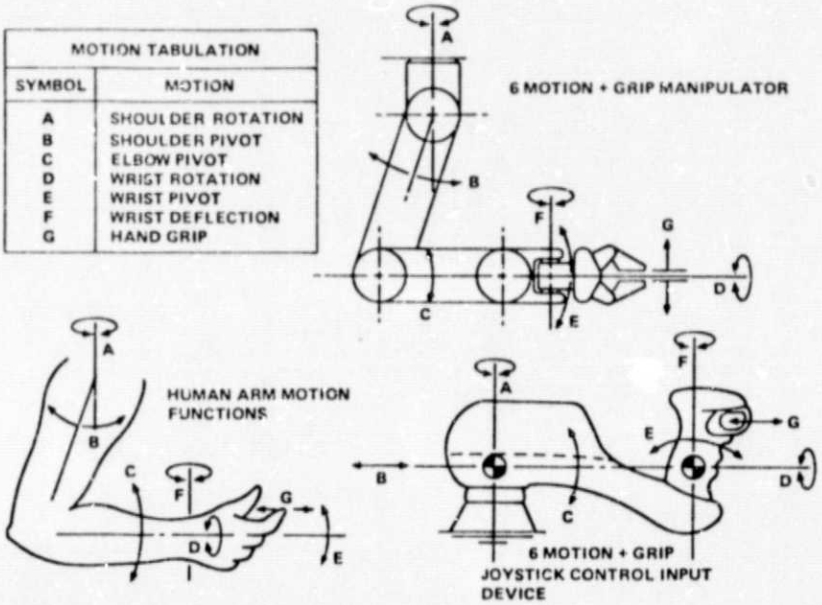
SIX-AXIS FORCE REFLECTING CONTROLLER

PROTO FLIGHT MANIPULATOR ARM CONTROLLER

The proto flight manipulator arm controller was developed for use at Marshall Space Flight Center. The controller is a unilateral rate driven controller.

The controller has a form not unlike a pistol grip mounted in place of the knob on a "dead man's " handle of an electric railway controller. Circular motion of the handle in an arc about the A axis corresponds to slewing the slave, pushing forward on the handle (held vertically) (B axis) moves the arm toward the load and pushing downward on the handle (held vertically) (C axis) lowers the end of the arm. The remaining motions of the pistol grip "joystick" mode, orient the end effector. Tilting the handle left to right about the D axis causes end effector roll; tilting the handle forward and backward about the E axis causes wrist pitch, and twisting the pistol grip about the vertical axis F causes wrist yaw. Pushing the button on the pistol grip closes the end effector.

MOTION TABULATION	
SYMBOL	MOTION
A	SHOULDER ROTATION
B	SHOULDER PIVOT
C	ELBOW PIVOT
D	WRIST ROTATION
E	WRIST PIVOT
F	WRIST DEFLECTION
G	HAND GRIP



POTENTIAL RTOP PROGRAMS

NO.	TITLE	FIELD CENTER
MAT-19	The Application of Microprocesser to the Power Factor Controller	Marshall Space Center
MAT-87	The Development of a High Energy Lixiscope for Pressure Vessel Inspection	Goddard Space Center
MAT-167	The Recycling of Paint Process Wash Water for Inplant Applications and Ecological Compatibility	Ames Research Center
MAT-168	Industrial Applications of the Orbital Tube Flaring Device	Marshall Space Center
MAT-169	The Development of an Underwater Robot with Deep Submergence Capability	Marshall/Ames Centers
MAT-175	The Development of an Automatic Measure, Cut and Strip Laser Wire Insulation Stripping System	Johnson Space Center
MAT-175	The Development of a Heavy Duty Laser Wire Insultation Stripping System for the Scrap Cable Industry	Johnson Space Center
MAT-199	The Magnetic Hammer and Its Application to Industry	Marshall Space Center
MAT-285	The Extension of Cutting Tool Life Using Ion Beam Applied Carbide Coatings	Lewis Research Space Center

ENCLOSURE (2)

MATeam Presentations

January 29, 1979	The Environmental Protection Agency (EPA) Noise Symposium Dallas, Texas.
February 27, 1979	Borg-Warner Corporation Arlington Heights, Illinois
February 28, 1979	Rockwell International Downey, California
*March 30, 1979	Valve Manufacturers Association Washington, D.C. Government Affairs Steering Committee
April 12, 1979	Artos Engineering Company New Berlin, Wisconsin
April 12, 1979	R.J. Wagner, Tubular Products Div. Milwaukee, Wisconsin
May 1, 1979	Society of Manufacturing Engineers Annual Meeting Detroit, Michigan
*May 10, 1979	Grotnes Machine Works Chicago, Illinois
May 14, 1979	Valve Manufacturers Association Annual Meeting Atlanta, Georgia
May 18, 1979	Illinois Tool Works Corporate Staff Rosemont, Illinois
June 4, 1979	Westinghouse Electric Machine Tool Forum Pittsburgh, PA
June 12, 1979	Robot Institute of America Steering Committee Meeting Cincinnati Milicron Cincinnati, Ohio

*Equipment Demonstration

ENCLOSURE (3)

<u>MATeam Presentations</u> (continued)

August 15, 1979	Strippit-Houdalle Corp. Eng. Staff Buffalo, N.Y.
September 6, 1979	Rock Island Arsenal Mfg. Eng. Branch Rock Island, IL
September 6, 1979	Deere & Company Mfg - R&D Moline, IL
October 16, 1979	American Society for Non-Destructive Testing Fall Conference St. Louis, Missouri

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NEWS RELEASE

Paula C. Norton
Ext. 4025

August 7, 1979

FOR IMMEDIATE RELEASE:

EARLY WARNING BEARING FAILURE SYSTEM AVAILABLE FROM NASA

CHICAGO--The National Aeronautics and Space Administration reports that vibration and stress waves can warn of bearing failure and indicate its nature.

In an extensive experimental study, sensors detected the noises at frequencies from 10Hz to 1MHz, and their output was displayed as functions of time and frequency. Correlation of the results with known faults in the bearings showed that these measurements can discriminate between defective and acceptable bearings and can help identify the nature of the defect. Discrete faults as small as about 0.003 inch (0.075 mm) have been discerned by all the sensors used. Faults of about 0.001 inch (0.025 mm) were not obviously discernable.

Vibration and stress waves in the ultrasonic frequency range contain the information or primary value; in fact, the count rate of signals above 100 Hz is the strongest indication of failure propagation, with larger changes in this quantity than those of other methods. Therefore, the selection of a suitable sensor is critical to the utility of the system. Sensor selection and instrumentation are discussed at length in the report on this study.

-MORE-

ENCLOSURE 4

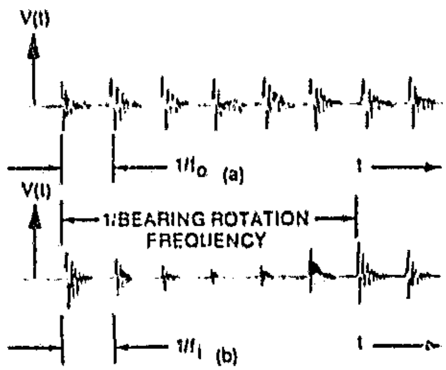
ADD ONE--EARLY WARNING BEARING FAILURE SYSTEM AVAILABLE FROM NASA

Excessive vibration and noise in a bearing can be traced to a surface fault that causes an impact to occur every time a defect is passed. The impact duration is generally quite short (on the order of 10 μs for a 207-size bearing with a surface fault about 10 mils (0.25 mm) wide). The frequency content of this impact extends well beyond the 100-kHz range and in some cases could even extend into the MHz range. This impact initiates a stress wave in the bearing system. Since the bearing system made of steel is a high Q structure, multiple reflection of the stress wave causes the bearing to resonate. Vibration and noise are the end products of this process.

Some characteristic frequencies employed for bearing-defect detection are the ball-pass frequencies for a discrete outer-race defect, inner-race defect, and ball defect. These frequencies are associated with the number of impacts per unit of time or the number of times a rolling element rolls over a defect either on the races or on the rolling element itself.

The waveforms below show typical signals in the time domain that would result from a single fault located on a raceway. In waveform (a) the decaying sinusoids repeat according to the ball-pass frequency for an outer-race fault, f_o. The decaying sinusoids relate to a natural resonance, and the individual ringdowns are quite alike in both amplitude and time duration. The wave in (b) shows the signal caused by an inner-race fault; though the sinusoids occur according to the ball-pass frequency for an inner-race fault, f_i, the individual bursts are not the same in amplitude or time duration.

ADD TWO--EARLY WARNING BEARING FAILURE SYSTEM AVAILABLE FROM NASA



The NASA system detects ultrasonic vibration waveforms generated by defects in the outer race and inner race of a ball bearing.

For additional information on this and other NASA technology, contact Mr. Victor Fischer (312)567-4264, NASA/IITRI Manufacturing Applications Team, 10 West 35th Street, Chicago, IL 60616.